SERIAL # _____

MODEL CCU1

CONSTANT CURRENT UNIT

INTENDED USE

Converts the constant voltage output of Grass Model S9, SD9, S44, S48, S11 and S8800 Stimulators and Model SIU5 Stimulus Isolation Unit to constant current.

PLEASE
DO NOT LOSE
THIS MANUAL

ONE MANUAL IS SHIPPED with each instrument.

No "shortages" recognized.

Additional copies may be purchased at cost by owners of the instrument, but it is necessary to give the exact model and serial numbers.

The cost $_____

GRASS INSTRUMENT DIVISION
Astro-Med, Inc. **Tel. 401-828-4000**
600 East Greenwich Avenue • West Warwick, RI 02893

Astro-Med, Inc
GRASS
INSTRUMENT DIVISION

GRASS INSTRUMENT DIVISION
Astro-Med, Inc. **Tel. 401-828-4000**
600 East Greenwich Avenue • West Warwick, RI 02893

WARNINGS

READ THIS BEFORE OPERATING CCU1

The output voltage and available current of this Constant Current Unit when coupled to Grass Stimulators, is large enough to be lethal or cause burns particularly with long durations and high current settings.

The state of the art is such that the potential danger to human and animal subjects from sustained stimulation even at low levels is still not completely understood.

NOTE: When using the CCU1 with Grass S44, S48, S88, S11 and S8800 Stimulators without Stimulus Isolation Units, the CCU1 output will be ground referenced, i.e., the negative output terminal will be at ground potential.

Grass Instrument Division of Astro-Med, Inc. waives any responsibility whatsoever for any injuries incurred to the operator of this instrument or to any animal or human subject as a result of the improper use or abuse of this accessory constant current unit.

MODEL CCU1 CONSTANT CURRENT UNIT
Table of Contents

M578H96

Astro-Med, Inc
GRASS
INSTRUMENT DIVISION

CONSTANT CURRENT UNIT
MODEL CCU1

For Constant Current Stimulation & DC Lesion Making

- **Current range: 50μA to 50 mA, pulses or DC**
- **Meter indicates preset current**
- **Stimulus current variation less than 5%**
- **Current reversal switch**

The output of Grass Stimulators approximates constant voltage. In some cases, however, the significant stimulus parameter desired may be current. Certain types of electrodes and/or experimental conditions can produce a significant variation in electrode impedance. When such variations are expected, the Grass Model CCU1 can be used to convert constant voltage stimulation to constant current. Current is maintained constant by means of an "active" stabilized feedback circuit. The CCU1 is limited at high current levels by the power available from the stimulator (see Figure 2.1.6). With electrode impedance of 1MΩ or higher, constant current with accurate wave shape is very difficult because of stray parallel resistances and capacitances. Applications include: cortical, depth, nerve and surface stimulation, EMG stimulation, tissue lesion making with predetermined DC constant current, and other cases where changes in the selected value of stimulus current is not desired.

SPECIFICATTIONS

Output Control	Switch and meter allow precise adjustment of current through dummy resistance before stimulation. Meter monitors average current during stimulation.
Output Current	50μA to 50mA in three decade ranges with maximum electrode impedance limited by stimulator source.
Output Voltage (compliance)	100V maximum limited by stimulator source (determined by the output current and electrode impedance).
Regulation	Current derivation is less than 5% for electrode impedances from Zero to the maximum electrode impedance.
Mode	Rectangular pulses or steady DC as supplied for the stimulator or stimulator/SIU combination.
Input Requirements	Unidirectional rectangular pulse or DC source, 150V maximum.
Physical Size	4.75" W x 3.25" H x 5.5" D (12.1cm x 8.3cm x 14cm) *Weight:* 1 lb. 12 ozs. (0.8kg)

S239H96

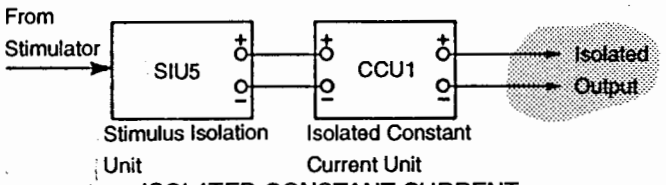
Astro-Med, Inc
GRASS
INSTRUMENT DIVISION

600 E. Greenwich Ave., W. Warwick, RI 02893 • Tel. 401-828-4000 • Toll-Free Phone: (USA only) 800-343-4039 • Fax 401-822-2430

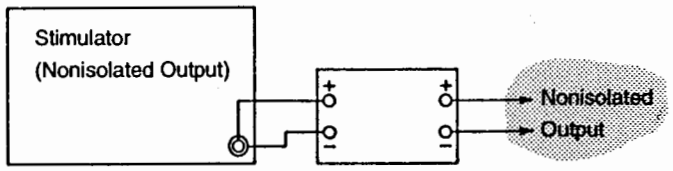
2 DESCRIPTION

2.1 Product Description

2.1.1 The Grass Model CCU1 Constant Current Unit is an accessory for the Grass Model S44, S48, S88, S11 and S8800 research stimulators. Basically, it converts the "constant voltage" output of the stimulator (and Model SIU5 Stimulus Isolation Unit) to a "constant current" output. It is important to note that the CCU1 does not contain circuitry to isolate the stimulus from ground. ***Therefore if stimulus isolation is required, either for safety or to minimize stimulus artifact, a separate Grass Model SIU5 Stimulus Isolation Unit must be used.***



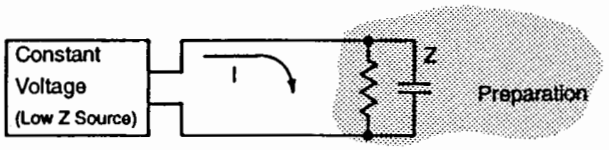
ISOLATED CONSTANT CURRENT
FIGURE 2.1.1a



NONISOLATED CONSTANT CURRENT
FIGURE 2.1.1b

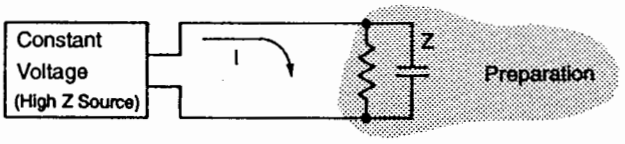
2.1.2 The CCU1 circuitry is powered from the stimulus voltage either from the stimulator direct (no isolation) or from the SIU5 (Stimulus Isolation Unit). No other power is required.

2.1.3 Why constant current? For many experiments, it is important to maintain the stimulus current at a constant level. After all, it is the current that does the work. With constant voltage output, the stimulus voltage is constant, but the current varies as the electrode impedance varies by Ohm's law (I = E/R). The stimulator (or SIU) output impedance is very low with constant voltage devices, so the stimulus current is determined by the electrode impedance, and is subject to variation as the electrode impedance varies.



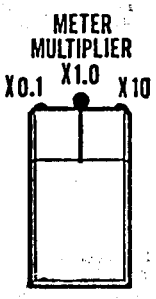
CONSTANT VOLTAGE SOURCE
(LOW IMPEDANCE SOURCE)
FIGURE 2.1.3

2.1.4 The output impedance of the CCU1 is very high, so the stimulus current delivered is determined by the CCU1, not the electrode impedance. Therefore, the stimulus current is held constant even though the electrode impedance may vary significantly during the procedure.



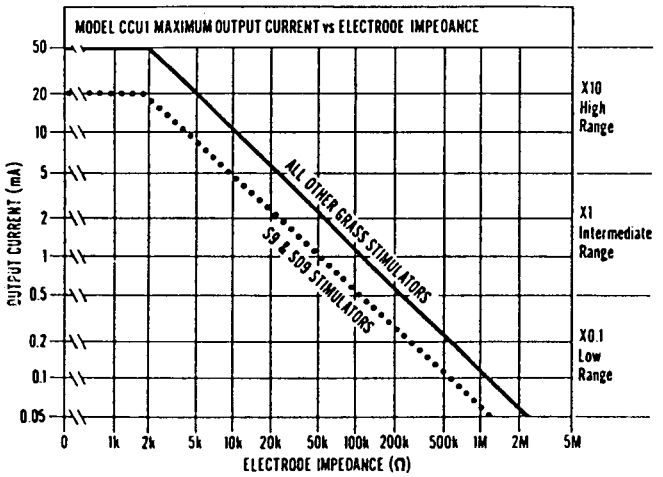
CONSTANT CURRENT SOURCE
"I" DETERMINED BY CONSTANT CURRENT GENERATOR
FIGURE 2.1.4

2.1.5 The output current of the CCU1 covers a fairly wide range; from 50 microamperes to 50 milliamperes, a range of 1000:1. There are three selectable current ranges:



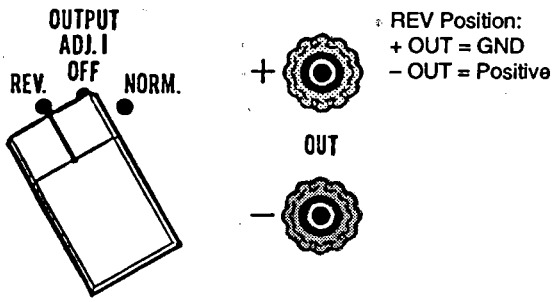
METER MULTIPLIER =
X0.1 = 50 to 500 µA
X1.0 = 0.5 to 5 mA
X10 = 5 to 50 mA

2.1.6 The maximum output current is determined by the input voltage and the CCU1 current range. The CCU1 is designed to accept a positive 150 volts from the stimulator or SIU5. With this input voltage, the "compliance" of the CCU1 is about 100 volts. Compliance is defined as the maximum voltage developed from the current selected x the electrode impedance. The compliance of the CCU1 is 100 volts. This means that whatever stimulus current selected x the electrode impedance cannot exceed 100 volts. If it does, the current will decrease. This is shown graphically in Figure 2.1.6.



ELECTRODE IMPEDANCE
FIGURE 2.1.6

2.1.7 When using the CCU1 without an SIU5 Stimulus Isolation Unit, it is important to understand that the negative output terminal will be at ground potential. Only positive currents can be delivered. Setting the CCU1 OUTPUT ADJ I switch to the REV position will cause the (+) output terminal to be grounded and the (–) terminal to be positive.



OUTPUT POLARITY
FIGURE 2.1.7

3 CONTROLS AND CONNECTIONS

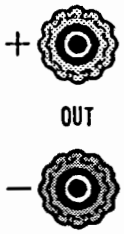
3.1 In Terminals

3.1.1 The CCU1 Input terminals are standard binding posts. They accept bare wires or 0.081-inch (2 mm) pins. Proper polarity must be observed; only connect the positive (+) stimulus output to the red (+) IN terminal and the negative (–), or ground, output to the black (–) IN terminal.

On Model CCU1B, ***GRASS SAFELEAD***™ terminals were used which accepted 0.059-inch (1.5 mm) diameter female connectors. Adaptors were provided to convert male pins for use with the *SAFELEAD*™ terminal.

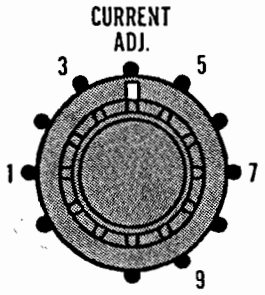
3.2 Out Terminals

3.2.1 The CCU1 Output terminals are the same type as the IN terminals. With an isolated stimulus connected to the CCU1, with proper polarity, and the OUTPUT ADJ I switch in the NORM position, the red output terminal will be positive (+), and the black output terminal will be negative (–).



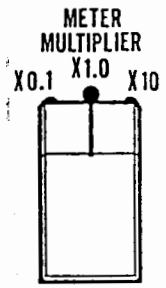
3.3 Current Adjust

3.3.1 The CURRENT ADJ (adjust) control is a continuously variable potentiometer that controls the value of stimulus current in the range selected by the METER MULTIPLIER switch.



3.4 Meter Multiplier

3.4.1 The METER MULTIPLIER is a three-position rotary switch used to select the current range. The X0.1 position selects a current range of 50 to 500 microamperes. The X1.0 range is 0.5 to 5 milliamperes, and the X10 range is 5 to 50 milliamperes.



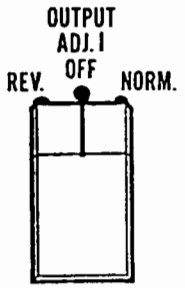
3.5 Meter

3.5.1 The METER is a current indicator, and is used in conjunction with the CURRENT ADJUST control and the METER MULTIPLIER switch to preset the desired stimulus current.

Note that this meter will only respond accurately to DC or long pulse durations and is only used during setup to preset the stimulus current. It will, however, indicate "average" current values based on the duty cycle (pulse duration/total period).

3.6 Output Switch

3.6.1 The OUTPUT ADJ I (adjust current) switch is a three-position switch used to control the stimulus polarity and preset the current. The REV (reverse) and NORM (normal) positions are used to reverse the stimulus polarity.



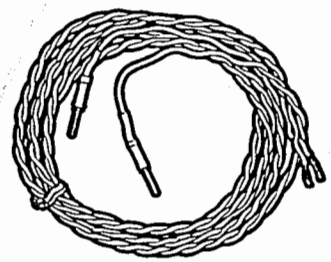
3.6.2 In the NORM position, the output polarity is red (+) and black (–). Turning the switch to the REV position inverts the output making the red terminal (–) and the black terminal (+). The OFF position disconnects the stimulus from the output terminals to allow changes to the stimulus current values.

4 SETUP AND OPERATING PROCEDURE

4.1 Setup: non-isolated (no stimulus isolation unit) ground referenced output

CAUTION:
The CCU1 is not recommended for human stimulation procedures. **It is assumed that a Grass Model S44, S48, S88, S11 or S8800 will be used with the CCU1.**

4.1.1 Set the stimulator POWER switch to OFF before making connections to the CCU1. Connect the cables from the stimulator to the CCU1 Input terminals observing proper polarity. The cables can be simply a twisted pair. No shielding is necessary. A pair of leads (#51677) is supplied with each CCU1. It can be used for connection from the stimulator CCU1 input to the CCU1, or from the CCU1 to the stimulating electrodes (CCU1 output).



4.1.2 Set the stimulator controls as follows:

Control		Setting
POWER	=	ON
STIMULUS OUTPUT		
lever switch	=	UP (ON)
STIM RATE	=	(not used during setup)
DELAY	=	(set to minimum)
DURATION	=	set to 5 to 10 seconds to allow setting of the CCU1 CURRENT ADJ
VOLTS	=	set to 150 volts (dial setting of 15 and X10)

Set the CCU1 controls as follows:

Control		Setting
METER MULTIPLIER	=	X0.1
OUTPUT ADJ I	=	OFF

4.1.3 Depress the stimulator MODE lever switch down to the SINGLE position to deliver a single 5 to 10 second 150-volt pulse to the CCU1. The stimulator monitor lamp should light for the 5 to 10 second period. Rotate the CURRENT ADJ control on the CCU1 while observing the CCU1 meter. The meter indicator should move left to right with clockwise rotation (current increase) of the CURRENT ADJ control. If the pulse times out before adjustment can be made, simply depress the SINGLE lever again to initiate another pulse.

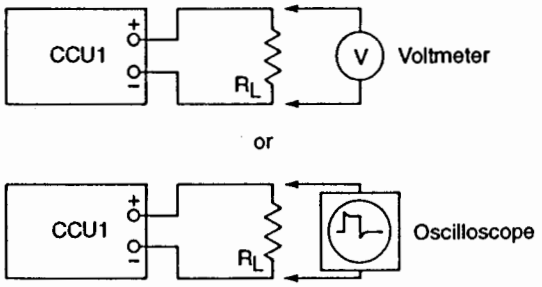
4.1.4 It should be possible to adjust the current between 0.5 and 5 on the meter for all three METER MULTIPLIER current ranges. This is a range of 50 microamperes to 50 milliamperes.

4.1.5 Set the stimulus current desired. For example, suppose a peak stimulus current of 2 milliamperes is desired. Set the METER MULTIPLIER to X1.0 to obtain a range of 0.5 to 5 milliamperes. With a single, 5 to 10 second long 150-volt pulse delivered to the CCU1, rotate the CURRENT ADJ control until the meter indicator is at "2" (milliamperes).

4.1.6 To test that the selected current is being delivered from the CCU1, it is possible to connect a "dummy load" across the CCU1 output terminals. The resistor selected x the current selected cannot exceed 100 volts (compliance). If working in the current range of 5 to 50 milliamperes, the resistor should not exceed 2000 ohms (2000 ohms x 50 milliamperes = 100 volts), or 20,000 ohms for the range of 0.5 to 5 milliamperes, or 200,000 ohms for the 0.05 to 0.5 milliampere range.

4.1.7 A DC voltmeter or oscilloscope can be used to measure the voltage across the dummy load resistor. The voltage divided by the dummy resistance used = the current (I = E/R). It should be within 5%. ***NOTE: Because of the high output impedance, working against stray capacitances in leads, etc., it is normal to observe "spiking" and transients in the CCU1 output voltage waveform as illustrated.***

"SPIKING" IN THE OUTPUT VOLTAGE WAVEFORM
FIGURE 4.1.7a



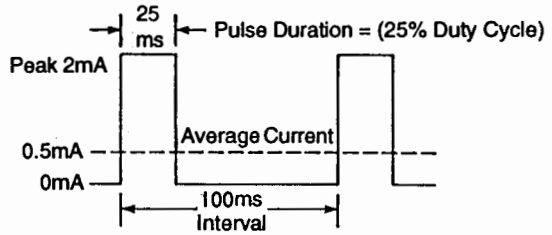
MEASURING VOLTAGE ACROSS A DUMMY LOAD
FIGURE 4.1.7b

4.2 Operating Procedures

4.2.1 Note that the meter, being an electro-mechanical device cannot respond to short pulse durations (low duty cycle). This is the reason for using a long pulse duration when initially adjusting the current. The peak current should be adjusted with the single long pulse duration first, then the stimulator switched to the parameters required for stimulation before the OUTPUT switch is set to the NORM or REV positions. The meter will then indicate the average current based on the "duty cycle" of the stimulus. For example, refer to Figure 4.2.1. If a peak stimulus current of 2 milliamperes is set as in Section 4.1.5, and the stimulus parameters are then adjusted as shown:

Control		Setting
STIM RATE	=	10 Hz (pulses/second) = (100 ms pulse interval)
PULSE DURATION	=	25 milliseconds = (25% duty cycle)

Each stimulus pulse is 2-milliamperes peak. The average value is 0.5 milliamperes, as indicated by the meter. The CCU1 will deliver 2 milliamperes for 25% of the cycle and zero milliamperes for the rest of the cycle. The meter will continuously read the average value; however, in this case the 0.5 milliampere. If the STIM RATE is low (below about 10 Hz), the meter indicator will fluctuate.



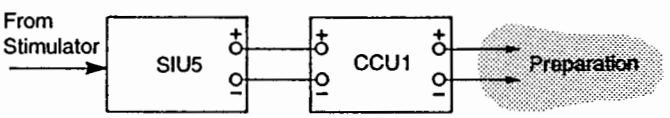
PEAK CURRENT AND AVERAGE CURRENT
FIGURE 4.2.1

NOTE: When Isolated constant current Is required, the Grass Model SIU5 must be used between the stimulator output and the CCU1 Input.

4.2.2 When using the Grass Model SIU5 to achieve isolation and produce constant current via the CCU1, connect the stimulator to the SIU5 with the cable provided. Connect the output of the SIU5 to the CCU1 Input terminals observing proper polarity. See Figure 4.2.2.

Set the SIU5 controls as follows:

Control		Setting
MULTIPLY INPUT VOLTS BY	=	1
COUPLING	=	DIRECT
POLARITY	=	NORM



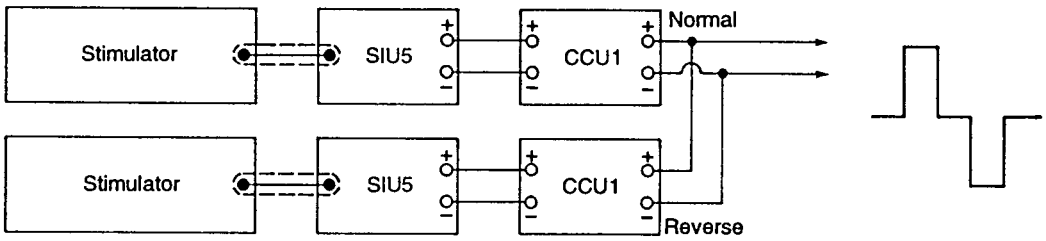
ISOLATED CONSTANT CURRENT UNIT CONNECTION
FIGURE 4.2.2

4.2.3 The procedure is the same as Steps 4.1.2 through 4.1.7. Note, however, that the CCU1 output is now isolated, neither output terminal is grounded, and it is possible to invert (reverse) the stimulus by the OUTPUT switch (NORM or REV).

4.2.4 **Biphasic Constant Current Stimulation:** The aforementioned procedures are for monophasic constant current pulses which only require a single-channel stimulator such as the Grass S44 or S48. Some procedures may require biphasic constant current stimulus patterns as a method of reducing stimulus artifact, or to minimize ion transfer from electrode to tissue.

4.2.5 A dual-channel Grass Stimulator such as the S88, S8800 or S11 can be used with two Grass SIU5s and two Grass CCU1s to deliver this type of stimulus pattern. The pattern is basically a twin pulse pair with the second pulse inverted to achieve the biphasic pattern. In this case, the second pulse is inverted at the output of the second CCU1. Refer to the diagram below.

4.2.6 In this setup, the S1 and S2 durations and the S1 and S2 currents are adjusted equal to achieve balance in the biphasic waveform. Notice also that the S2 pulse follows the S1 pulse by some small delay to prevent pulse overlap. This delay is controlled by the S2 DELAY circuit.



BIPHASIC PATTERN
FIGURE 4.2.5

4.3 Making Current Adjustments while Stimulating

4.3.1 In some applications, it may not be necessary to "preset" the stimulus current as described in the preceding steps. For example, if it is only desired to stimulate a preparation to obtain a certain result, the CCU1 and stimulator can be set to deliver the stimulation paradigm and the CCU1 current increased while stimulating.

4.3.2 For this type of procedure, it is wise to start with the CCU1 range set to X0.1 and the CURRENT ADJ control counterclockwise (minimum current). Increase the CURRENT ADJ control slowly until the desired current level is obtained. If the current is too low, return the CURRENT ADJ control to the maximum counterclockwise position, turn the METER MULTIPLIER to X1 and start again slowly increasing the CURRENT ADJ control. If still not enough current, repeat using the X10 position of the METER MULTIPLIER.

4.3.3 If it is desired to know the peak current value used, simply leave the CCU1 controls as they had been adjusted, set the CCU1 OUTPUT ADJ I switch to the OFF position, and set the stimulator to deliver one long, single pulse of 5 to 10 seconds to the CCU1. (See Section 4.1.3.) Take note of the value indicated on the CCU1 meter. This is the peak stimulating current used during the procedure. The average value can be determined from the duty cycle used in the procedure.

4.4 Using the CCU1 as a DC Lesion Maker

4.4.1 **Application:** The Grass CCU1 is an excellent source of constant DC current for controlled small lesions in tissue. A DC voltage of 100 to 150 volts has to be supplied from an external source such as a Grass Stimulator, Model S44, S48, S88, S11 or S8800 or a power supply to the CCU1. The power source must be able to deliver up to 50 milliamperes, or at least the amount of lesion current needed.

4.4.2 DC current does cause migration of the metal used for electrodes, so the procedure is best limited to using a large diffuse metal electrode attached to the preparation through a saline saturated cotton pad. This should be the negative electrode. The lesion making electrode should be positive and preferably made of platinum for the least contamination of tissue by the electrolysis action.

4.4.3 Constant current DC small lesion making has many attractive features. It is inexpensive, easily controlled and free from electrode capacitance effects. In contrast to radio frequency lesion making, it suffers from metal deposits by electrolysis and does not provide as localized a lesion.

4.4.4 **Use:** To use as a DC lesion maker, proceed as follows:

a. Connect the CCU1 to a 150 voltage source with input terminals red to (+) and black to (–).

b. Set the OUTPUT ADJ I switch to OFF and the METER MULTIPLIER switch to the desired range.

c. Set the CURRENT ADJ control to the exact current desired.

d. Connect the electrodes to the output with the indifferent electrode to black (–) and the local lesion making electrode to red (+).

e. Turn the OUTPUT switch to NORM.

f. Turn the OUTPUT switch to OFF at the end of timed interval.

NOTE: It would be desirable to control the time ON with a stop watch. Amounts of current which produce the desired lesion in 30 to 150 seconds are most desirable.

5 SERVICE AND MAINTENANCE

5.1 Service and Maintenance

5.1.1 The history of the CCU1 has singularly been free from malfunctions. If any difficulties arise in the operation, make sure that the malfunction is in the CCU1 and not the stimulator, SIU or connecting cables.

5.1.2 If, after consulting the Service and Maintenance Sections in the appropriate Stimulator manual or SIU manual, the CCU1 appears to be malfunctioning, contact the Technical Support Services Department of Grass Instrument Division of Astro-Med, Inc. for further information.

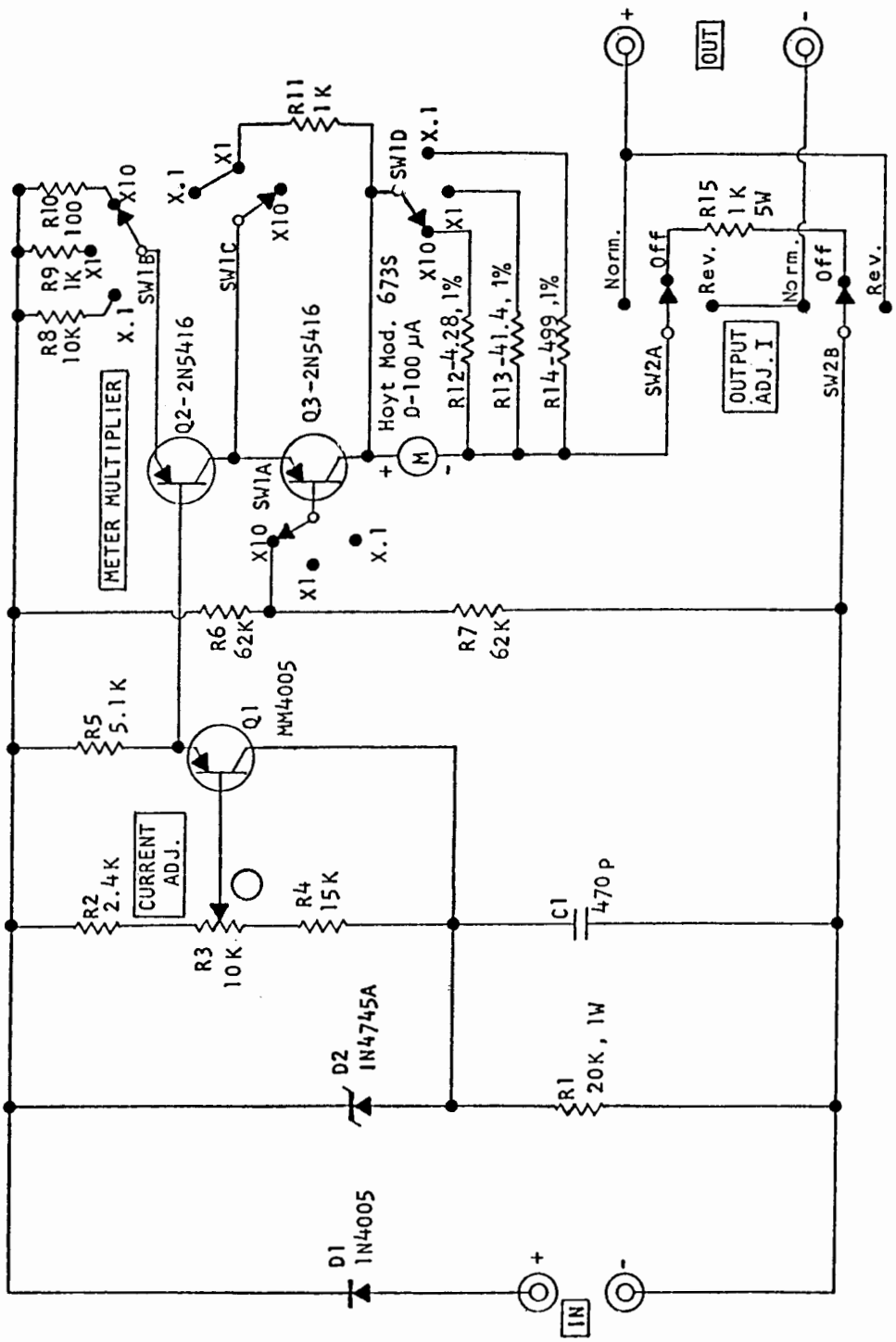
6 CIRCUIT DIAGRAMS

6.1 Explanation of Circuit Diagrams

6.1.1 This manual contains all of the circuit diagrams with values of components for all models which have evolved from the basic design. The succession of design changes are indicated by the last letter subscript and are in alphabetical order. For instance, the basic design CCU1 is followed with a letter subscript such as A, B, C, D, etc. as in CCU1F which represents a change from the CCU1E. There may have been minor changes in a few components within any model with the same subscript letter. The circuit presented here with a certain subscript letter would be the last one prior to the introduction of a more substantial change such as when the CCU1F supersedes the CCU1E. The last subscript circuit in this manual is the latest one available at the date of publication.

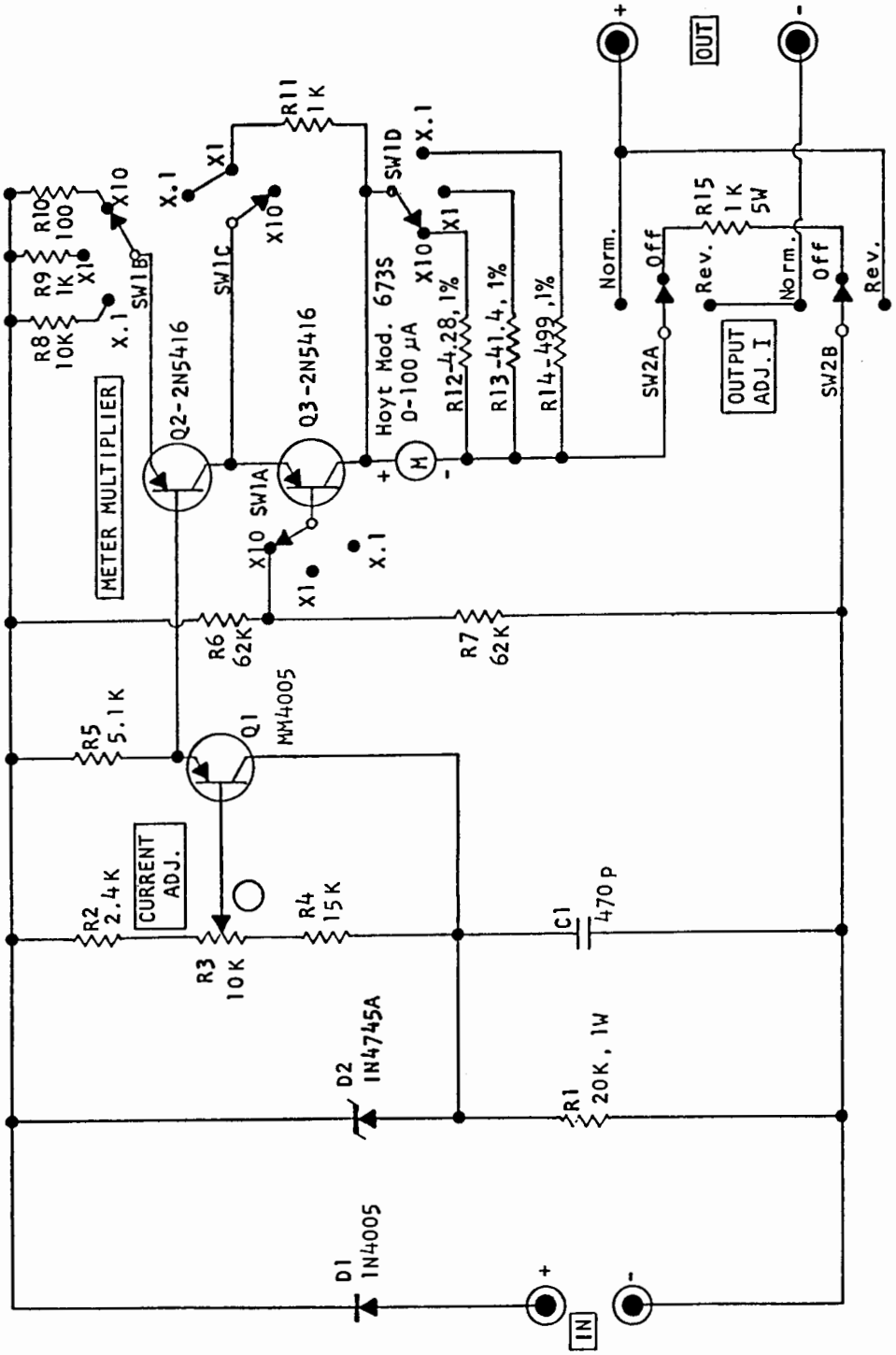
To identify the appropriate circuit, check the last letter subscript of your instrument model number and identify with the circuit print with exactly the same model number.

CIRCUIT DIAGRAMS
Section 6.1



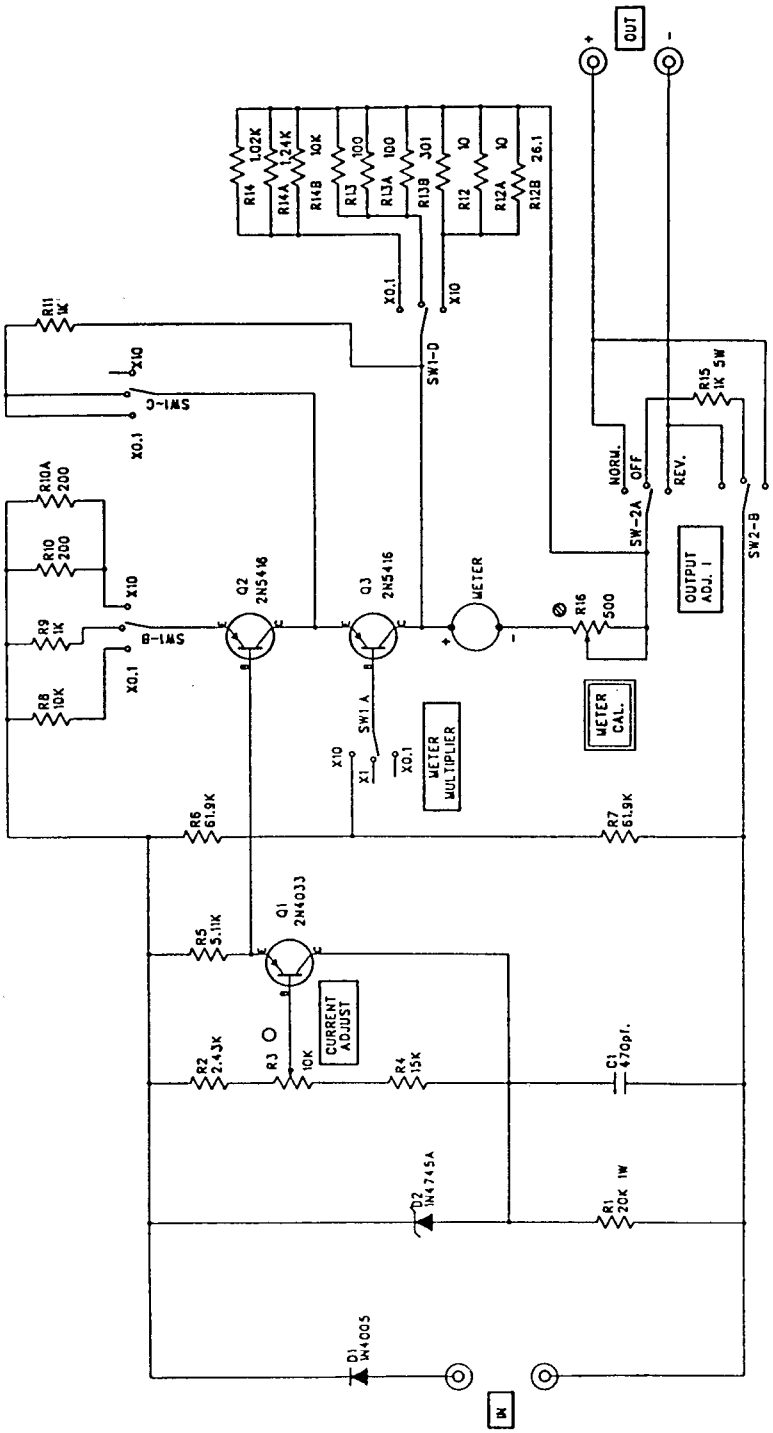
MODEL CCU1Δ CONSTANT CURRENT UNIT CIRCUIT DIAGRAM - #50081-1
(Part 1 of 1)

CIRCUIT DIAGRAMS
Section 6.1



MODEL CCU1B CONSTANT CURRENT UNIT CIRCUIT DIAGRAM - #50081-2
(Part 1 of 1)

CIRCUIT DIAGRAMS
Section 6.1



MODEL CCU1C CONSTANT CURRENT UNIT CIRCUIT DIAGRAM - #50081-4
(Part 1 of 1)

GRASS TELEFACTOR™
An Astro-Med, Inc. Product Group

ASTRO-MED ASTRO-MED ASTRO-MED ASTR

FOR INFORMATION
fax, phone, write
or e-mail:

Customer Service
for ordering instruments, chart paper, recording accessories and catalog and quotation requests.

Instrument Applications
for technical assistance.

Technical Support Services
for troubleshooting advice, repair and replacement service.
Please identify the model and serial number of your instrument.

SERVICE

HERE'S WHAT TO DO

OUR WARRANTY IS FOR ONE YEAR

WE HAVE PROMPT, EFFICIENT FACTORY SERVICE TO BACK IT UP

However, our warranty does **not** cover transportation costs if repairs become necessary. Universities and hospitals have Purchasing and Receiving Departments that must be informed.

A PURCHASE ORDER NUMBER OR AUTHORIZATION IS NECESSARY.

Therefore, we urge you to contact them before contacting us.

IF, *"Instrument was damaged in transit"*

a. Save packaging materials for inspection by carrier's agent,
b. Obtain a joint inspection report from the carrier who delivered the instrument,
c. Report full details immediately to Grass-Telefactor, An Astro-Med, Inc. Product Group

IF, *"It doesn't work"*

a. We can **ADVISE** a solution to your problem but we need all the facts, including model and serial number of the instrument and symptoms of the instrument malfunction.
b. We can **REPLACE** damaged or malfunctioning units.

GRASS TELEFACTOR™
An Astro-Med, Inc. Product Group

X381J99

600 East Greenwich Avenue, West Warwick, RI 02893 • Tel. 401-828-4000 • Toll-Free Phone: (USA only) 877-472-7779 • Fax 401-822-2430
e-mail: techserv@astro-med.com

GRASS TELEFACTOR™
An Astro-Med, Inc. Product Group

ONE-YEAR LIMITED WARRANTY

ASTRO-MED ASTRO-MED ASTR

JULY 1995

SUPERSEDES ALL PREVIOUS WARRANTIES

GRASS-TELEFACTOR, An Astro-Med, Inc. Product Group WARRANTS this instrument to the original purchaser (who is the same end user) only. The warranty is not transferable. Material, workmanship and performance as specified are guaranteed:

1. if the *GRASS-TELEFACTOR* seal (when present) is not broken,
2. if there is no evidence of abuse, attempted repairs or modifications without Grass-Telefactor authorization,
3. only if genuine Grass-Telefactor replacement parts are used,
4. only if the instrument is used for its specified uses,
5. if the instrument has not been resold or used in a larger system incorporating non-Grass-Telefactor products not approved by Grass-Telefactor for compatibility.

THIS WARRANTY IS BINDING FOR ONE YEAR from date of initial delivery and is limited to: servicing and/or replacing any instrument or part thereof (except batteries and expendable supplies) returned to the factory for that purpose with transportation charges prepaid and which to the company's satisfaction are found to be malfunctioning.

WARRANTY DISCLAIMERS

Any implied warranties arising out of this sale, including but not limited to the implied warranties of merchantability and fitness for a particular purpose, are limited in duration to the above one (1) year period. Grass-Telefactor. shall not be liable for loss of use of the instrument or other incidental or consequential costs, expenses or damages incurred by the purchaser.

Some states do not allow the exclusion or limitation of implied warranties or consequential damages, so the above limitations or exclusions may not apply to you. This warranty gives you specific legal rights, and you may also have other rights that vary from state to state.

DAMAGE UPON ARRIVAL

Each instrument leaves our plant after rigorous tests and performs as specified. The instrument may receive rough handling and damage in transit. The shipment is insured against such damage. The buyer must report in writing immediately any concealed or apparent damage to the last carrier. Report any damage also to us, and issue an order for replacement or repair. Our invoice for such service will then be evidence in the claim. Hold all packaging material.

MALFUNCTIONS OCCURRING WITHIN WARRANTY PERIOD

Our prices include replacement of malfunctional parts, modules and even complete instruments when all conditions of sale are met and if we decide it necessary.It does not include:

1. provide for any transportation charges,
2. provide for services not performed or authorized by us,
3. provide for the cost of repairing instruments which have obviously been abused, modified, or subjected to non-intended uses or to unusual environments for which they have not been designed.

We will discuss by phone or letter suspected malfunctions or aspects of instrument operation which may be unclear. Advise us of the nature of the malfunction before returning an instrument for repair. Many times a simple suggestion will solve the problem without returning anything. In the case of a malfunction properly diagnosed by Grass-Telefactor as being within a "plug-in" module, circuit board or other part which can readily be replaced without impairment of the instrument fidelity by a procedure which does not require a service man, then it is the responsibility of the owner to make such replacement under the direction of the company with a suitable replacement furnished by the company under the terms of the warranty. The owner has the responsibility for the return or to bear the cost of the replaced unit when requested.

WARRANTY ON SPECIFICATIONS

Grass-Telefactor reserves the right to make changes in design and specifications without notice and without any obligation to install such changes in units previously purchased.

Grass-Telefactor warrants each instrument to satisfy printed specifications available to the purchaser on formal request thirty days prior to date of scheduled delivery. Specifications are the average of typical measurements made on production units under controlled conditions. Statistical variations in individual units due to normal component variations are to be expected and should not alter the intended use of the instrument. However, when parameter characteristics are critical, tolerances are specified and guaranteed. Operating characteristics can be expected to change slightly from printed specifications with age and long term use.

Unless the exact tolerances of any parameter of any instrument are specified on the purchase order and specifically agreed to by Grass-Telefactor it is assumed that our standard production tolerances will satisfy all contractual responsibility.

GRASS TELEFACTOR™
An Astro-Med, Inc. Product Group

X314G95

600 East Greenwich Avenue, West Warwick, RI 02893 • Tel. 401-828-4000 • Toll-Free Phone: (USA only) 877-472-7779 • Fax 401-822-2430